www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2019; 8(5): 155-160

www.thepharmajournal.com
Received: 06-03-2019
Accepted: 10-04-2019

M Naga Sai Srujana
Department of Foods and Nutrition, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, Telangana, India

B Anila Kumari
Post Graduate & Research Centre, Department of Foods and Nutrition, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, Telangana, India

W Jessie Suneetha
Department of Foods and Nutrition, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, Telangana, India

P Prathyusha
Department of Foods and Nutrition, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, Telangana, India

Correspondence
B Anila Kumari
Post Graduate & Research Centre, Department of Foods and Nutrition, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, Telangana, India

Processing technologies and health benefits of quinoa

M Naga Sai Srujana, B Anila Kumari, W Jessie Suneetha and P Prathyusha

Abstract
Quinoa (*Chenopodium quinoa* Willd) is a stress-tolerant pseudo cereal cultivated along the Andes for the last 7000 years, challenging highly different environmental conditions with Peru and Bolivia being the main producers. The edible seeds of quinoa are small, round and flat. Seed colors can range from white to grey and black, or can be yellow and red. Because of its high nutritional characteristics, United Nations General Assembly has therefore declared 2013 as the "International Year of Quinoa. Quinoa is a rich source of protein (12-16.5%) with protein quality equivalent to that of casein. In addition, this “wonder grain” is gluten free, rich in bioactive compounds like antioxidants, polyphenols, flavonoids, vitamins and minerals that imparts various health benefiting characteristics to this grain.
Human health and food security have become increasingly important with the advents of climate change, accelerated human population growth, rise of metabolic disease, and increasing median age of the population. About 1 in 8 individuals are suffering from chronic undernourishment, while diabetes, obesity, and other metabolic disorders resulting in a mounting prevalence of age-related disorders such as fragility, cardiovascular diseases, and osteoporosis.
Functional products prepared with different processing techniques such as quinoa cereal bar, quinoa flakes, quinoa pasta, have been known to have various health benefits and to be effective in cases of obesity, cardiovascular diseases, hypertension, and celiac disease. Grain processing techniques like soaking, germination and malting, are known to improve the nutrient content and decrease the antinutrients in quinoa grain.

Keywords: food security, pseudo cereals, quinoa, breakfast cereals, antioxidant properties of quinoa

Introduction
Globalization of agriculture and consequently its industrialization seem inexorable with negative side effects being felt throughout India resulting in biased technological development of some high demanding plant species and monoculture production with reduced genetic diversity in agriculture. As a consequence, Indian food security has become increasingly dependent on only a handful of crops (Izdajatelj, 2010) [21].
The narrowing of the number of crops upon which global food security and economic growth depend has placed the future supply of food and rural incomes at risk. The mentioned facts with profound environmental consequences and concern for loss of crop varieties stimulate organizations and scientists worldwide in retrieving, researching and disseminating the knowledge in production and utilization of neglected, disregarded, underexploited and new plant species, or so called alternative crops. Alternative crops plant species are used traditionally for food, fiber, fodder, oil or medicinal properties. Those are an under-exploited potential crop to contribute to food security, nutrition, health, income generation and environmental services (Hafele and Sassin, 1979) [20].
Pseudocereals are defined as fruits or seeds of non-grass species that are consumed in very similar way as cereals having nutritive value very much competitive to conventional crop, in most cases even better. Quinoa is a pseudo cereal belongs to (*Chenopodiaceae*) family. Quinoa fruits are achenes, comprised of a single seed enclosed by an outer pericarp (FAO 2011) [13].
Quinoa has been traditionally used by several indigenous peoples of South America (Bhargava and Srivastava 2013) [2]. The seeds have been consumed similarly to rice, prepared in soup, puffed to make breakfast cereal, or ground to flour to produce toasted and baked goods (Cookies, breads, biscuits, noodles, flakes, tortillas, pancakes) (Bhargava *et al*., 2006) [1].
Quinoa leaves have also been eaten similarly to spinach (Oelke *et al*., 2012) [32] and the germinated quinoa that is quinoa sprouts have been incorporated in salads (Schlick and Bubenheim. 1996) [43].

Quinoa seeds can be fermented to make beer, the traditional alcoholic beverage from South America called "chicha" (FAO 2011) [13].

The edible seeds of quinoa are small, round and flat. Seed colors can range from white to grey and black, or can be yellow and red. It is consumed as breakfast food as well as staple food similar to maize and potato (Nowak *et al*. 2015) [31].

Nutritional composition: Quinoa contains from 2% to 10% fat. Quinoa is a rich source of essential fatty acids such as linolenic (18:2n-6: 52%) and linoleic (18:3n-6: 40%) (Jancurová *et al.* 2009) [23]. Quinoa has a similar amino acid composition as rice with higher contents in especially lysine (4.8 g/100 g protein and threonine (3.7 g/100 g protein), which are in general the limiting amino acids in conventional cereals like wheat and maize (Dini *et al*. 2004) [10].

Zevallos *et al*., 2012 [50] reported that certain quinoa cultivars have celiactoxic epitopes (location on an antigen that interacts with antibodies) that can activate immune responses in some patients with celiac disease. Quinoa is considered gluten-free grain because it contains very little or no prolamin (James, 2009) [22].

Quinoa leaves and seeds (Graf *et al*. 2015) [19]


Fig 1: Seeds and Quinoa leaves

Quinoa grains based amount of saponins, the grains were classified as bitter. (Nickel *et al*. 2016) [30]. Washing caused a reduction in the antinutritional compounds, but the levels remained unchanged after cooking (with and without) pressure and toasting. An abrasion degree of 30% was necessary to obtain sweet quinoa with total saponin content lower than 110 mg/100 g (Gómez-Caravaca *et al*., 2014) [18].

Vitamin C, total Polyphenols and antioxidant activity in raw, domestically processed and industrially processed quinoa has been given in Table 1. (Kaur *et al*., 2016) [16]. Antioxidant activity and phenolic content have been reported to be greatly affected by domestic processing (Dini *et al*., 2010) [9].

Table 1: Effect of processing on vitamin C, TPC and TFC content of quinoa

Processing	Vitamin C	TPC	TFC
Raw quinoa	13.43	43.2	11.4
Soaked	15.09	31.1	7.2
Germinated	19.38	101.2	18.02
Industrially processed	9.45	34.6	5.80

Germination: Soaked *for 12hrs at* 20°C in a BOD for 72 hours (Carciochi, 2014) [6].

Processing techniques: Post harvesting and prior to marketing, grains undergo industrial processing, mainly the process of dehulling or decortications, to remove the outer layers of the grain. Dehulling is known to improve grain quality by lowering the content of antinutrients and enhancing the sensory parameters, hence the acceptance and pallatabilty of the grain. Despite these benefits of dehulling, it reported to cause loss of nutrients from grains. Thus, to minimize loss nutrients and increase bioavailabilty of nutrients, researchers recommend use of common traditional domestic processing methods for grains (Table 2). Soaking and germination are the commonly used methods for domestic processing of seed. Antioxidant activity and phenolic content have been reported to be greatly affected by domestic processing (Table 1).

Germination of quinoa results in oleic acid increased, but linoleic acid decreased in NL (non polar lipids), GL and PL. The ratio of saturated, monounsaturated and polyunsaturated fatty acids of NL, and PL approached 3: 4: 3. After 72 hr germination, the ratio of Omega3/6 became o.25 in GL (glycolipids) (Park and Naofumi, 2004) [33].

The tannin and phytate contents could not be detected after steeping and germination (Kanensi, *et al*., 2011) [25]. Germination resulted in a 2 fold increase in antioxidant activity after 3 days of germination, the amounts phenolic acids and flavonoids increased 8.57 fold, and 4.4 fold respectively. (Carciochi, *et al*., 2013) [5].

Germination and subsequent oven-drying was shown to be a good process to improve the phenolic content and antioxidant activity of quinoa seed and can be used in functional food formulations. These germinated products contain essential fatty acids that play an important roles in brain development, insulin sensitivity, prostaglandin metabolism, a lower ratio of omega-6: omega-3 fatty acids that helps in cardiovascular health, immunity, inflammation, and autoimmune diseases (Galvez *et al*., 2010) [16].

Fermentation was carried out naturally by the microorganisms present in the seeds or by inoculation with two *Saccharomyces cerevisiae* strains (used for baking and brewing) there was decreased content of ascorbic acid and tocopherol content and the phenolic compounds and antioxidant capacity were improved. (Carciochi, *et al*., 2016) [4].

Malting with a moderate thermal treatment is considered an effective process to enrich antioxidants in quinoa grains for their further use as functional ingredient in the production of gluten-free foods and beverages (Carciochi, *et al*., 2016) [4].

Dehydration of quinoa between 70 and 80 °C showed an increase in vitamin E content and the antioxidant capacity was also increased on dehydration at 40, 50 and 80 °C due to temperature/drying time equivalent processes. The dehydration of quinoa led to reductions of 10% in proteins, 12% in fat and 27% in both fiber and ash content (Miranda *et al*., 2010) [28].

The heat application to quinoa has shown reduction of anti nutritional factors in *Chenopodium quinoa* seeds (Silva *et al*., 2015) [45]. Heat processing is required for complete digestion of food proteins. These processes significantly affect the protein structures, and consequently, their resistance to digestion.

Extrusion processing is used to make extruded ready-to-eat (RTE) breakfast cereal from quinoa, fortified with cranberry concentrate, the extrudates contain higher phenolic values which may be due to the formation of maillard products at higher barrel temperatures and maximum anthocyanins content of 9.63 mg / kg d.m at 140 ˚C (Chandran, 2015) [8]. Extrusion results in inactivation of antinutrients, destruction of aflatoxins and increasing the digestibility of fiber (Saalia and Phillips, 2011) [40]. Extrusion results in transformation of insoluble dietary fiber to the soluble dietary form in addition to the formation of resistant starch and enzyme resistant glucans through the process of transglycosidation (Repo-Carrasco *et al*., 2009) [36].

Higher extrusion temperatures in the extrudates of quinoa caused oxidation of unsaturated fatty acids resulting in decreased content of unsaturated fatty acids and inactivation of antinutrients such as lectin and antitrypsin inhibitors resulting in the increase of protein digestibility (Chandran, 2015) [8].

Nutritionally improved, gluten-free spaghetti (NIS) with broad bean (*Vicia faba*) and quinoa (*Chenopodium quinoa Willd*) showed significantly increased NPU. One NIS-portion supplied 10–20% of recommended fiber daily intake. Addition of quinoa flour had a positive effect on the FeDa% as did broad bean flour on ZnDa%. EDTA increased Fe- and ZnDa% in all NIS-products, but it also impaired sensorial quality (Giménez, *et al*., 2016) [17].

Consumption of quinoa flakes results in significant reductions in serum triglyceride, total cholesterol and LDL-cholesterol and an increase in GSH – glutathione stimulating hormone, vitamin E concentrations and lower retention of total tocopherols and α-tocopherol in the extrudates (Carvalho *et al.,* 2013) [7].

Roasted quinoa seeds flour at 177 °C for 15, 30 and 45 min resulted in increase in peak and final viscosity of cakes, weakening of starch–protein interactions and swelling of the starch granules, leading to granule rupture and decreased geometric mean diameters with elevated roasting temperatures (Rothschild *et al*., 2014) [37].

Baking: Baking red and yellow quinoa seeds resulted in increased total phenolic content and antioxidant activity. This increase in antioxidant activity might have been due to the Maillard reaction products produced during the thermal processing (Brend *et al*., 2012) [3].

High pressure – high temperature processed quinoa products resulted in increased iron solubility two to four times after soaking and germination, 3-5 times after fermentation, 5-8 times after fermentation of the germinated flour. 5-8 times in magnesium content has been improved after cooking and baking and copper content was reduced by 28% after processing **(**Ruiz, G.A *et al*., 2016) [39].

Table 2: Processing techniques

Quinoa-derived product	Production method	Uses	Reference
Treated seeds	Superheated steam treatment to expand the seeds and reduce cooking time. Mechanical abrasion, washing, or a combination to debitter seeds.	Favoring or texturizing agents in food products	Thomas, 1995 [48] Scanlin and Burnett, 2010 [41]
Beverages	Seeds are soaked, malted, kilned, mashed, cooled, and fermented with yeast	Gluten-free fermented alcoholic beverage	Kamelgard, 2013 [24]
	Mixing of quinoa extract, tiger nut (Cyperus esculentus), and α-amylases for hydrolysis of starches to thermostable maltodextrin within a beverage formulation.	Substitute for animal or plant-derived milk	Felipe, 2003 [15]
Protein concentrate	Extraction and precipitation via alkali or enzyme treatment	Used in foods, animal food, or sports performance and recovery	Enrione, 2013; [11] Kruger, 2012; [27] Pouvreau, 2014; [35] Scanlin and Stone 2009 [42]
Lipid	Extraction and molecular distillation to obtain a refined oil	Dermatological use	Msika, 2012 [29]
Carbohydrate	Extraction of maltodextrin via alkali or enzyme treatment of quinoa flour to produce a gel-form to deliver quinoa-derived peptides. Use of quinoa starches of specific shape and particle size	Cream substitute that mimics the mouth feel of fat/cream in food	Singer *et al*., 1990 [46]

Near-infrared spectroscopy (NIRS) technology allowed the determination of protein (16.0–20.2 g $100g^{-1}$), crude fiber (1.8–3.1 g $100g^{-1}$), fat (4.4–7.5 g $100g^{-1}$), calcium (298.8–1164.5 mg kg^{-1}), iron (0–948.5 mg kg^{-1}) and phosphorus (2735.0–4543.3 mg kg^{-1}). Provides an alternative for the determination of chemical compounds of quinoa, faster and at lower cost, with results comparable with chemical methods **(**Escuredo *et al*., 2014) [12].

Pineli *et al*. 2015 [34] developed quinoa milk with increased amount of protein and low glycemic index do not contain any prolamins that are toxic for people who suffer from celiac disease. This is a novel alternative to current milk- products which has a beneficial effect for lactose intolerance population and is an excellent substitute for lactose intolerance.

Takao *et al*., 2005 [47] extracted the protein fraction (QP), The QP supplementation significantly prevented the increase in plasma and liver total cholesterol level, cholesterol biosynthesis was suppressed through the expression of mRNA of --hydroxy---methylglutaryl coenzyme A reductase in the liver, whereas the expression of cholesterol-1a-hydroxylase, a cholesterol catabolic enzyme, was found to be stimulated. This QP binds with bile acid, potentially reducing the micelle cholesterol solubility and inhibiting intestinal tract cholesterol absorption there by hypo cholesterolemic effect.

Heath benefits of quinoa products: It is stated that quinoa may benefit high-risk group consumers, such as children, the elderly, high-performance sports people, individuals with lactose intolerance, women prone to osteoporosis, people with anemia, diabetes, dyslipidemia, obesity, and celiac disease due to its properties including a high nutritional value, therapeutic features, and gluten-free content (Table 3). These features are considered to be linked with the existence of the fiber, minerals, vitamins, fat acids, antioxidants, and especially phytochemicals in quinoa, and they provide quinoa a big advantage over other crops in terms of human nutrition and health maintenance.

Table 3: Health benefits of quinoa products.

Therapeutic application	Treatment	Endpoints (measured before and after intervention) and outcomes	Conclusions	Reference
Child growth & development	Infant food formulated from quinoa (100 g × 2/d for 15 days) compared with no treatment	↑ Plasma levels of IGF-1, a marker of malnutrition, known to increase body weight gain	Quinoa-based infant food may play a role in reducing childhood malnutrition	Ruales, 2002 [38]
Celiac disease	Cooked quinoa (50 g/d for 6 weeks)	All gastrointestinal parameters surface-enterocyte cell height, number of intra-epithelial lymphocytes per 100 enterocytes) Improved, serum lipid levels remained normal with small decrease in total cholesterol, LDL, HDL, and triglycerides	Quinoa is safe for consumption by celiac patients	Zevallos, 2014 [51]
Risk of cardiovascular disease	Quinoa cereal bar daily for 30 days	↓ Triglycerides ↓ Cholesterol ↓ LDL	Quinoa intake may reduce risk of developing cardiovascular disease	Farinazzi-Machado, 2012 [14]
Postmenopausal symptoms	Quinoa flakes (QF) compared with corn flakes (CF), 25 g/d for 4 weeks	QF consumption increased protein and fiber intake but not total caloric intake ↓ triglycerides, ↓ TBARS ↓ Cholesterol, ↓ LDL, ↑ GSH	Quinoa intake beneficially modulates metabolic parameters	De Carvalho, 2013 [7]

Conclusion

Pseudocereals are potential crops for food security across the world. Owing to their high nutrient content and quality of proteins. This has low glycemic effect on the blood glucose levels which has a protective effect against diabetes, cardio vascular disease. Quinoa essentially composed by globulins and albumins which contain less glutamic acid and proline than prolamins, and high essential amino acids content such as lysine, methionine, cystine, and histidine. Quinoa has the potential to shed its underutilized status and become an important industrial and food crop of the 21st century. Processing of quinoa resulted in easy digestion and absorption of protein, reduction of antinutritional contents like saponins, phytates, and tannins and increased bio availability of minerals like magnesium, manganese, iron and zinc which has beneficial results in reduction and prevention of physiological and neurological disorders due to the application of processing techniques.

References

1. Bhargava A, Shukla S, Ohri D. *Chenopodium quinoa*-An Indian perspective. International Journal of Industrial Crops and Products. 2006; 23:73-87.
2. Bhargava A, Srivastava S. Quinoa: Botany, Production and Uses. Boston, MA: CABI, 2013.
3. Brend Y, Galili L, Badani H, Hovav R, Galili S. Total phenolic content and antioxidant activity of red and yellow quinoa (*Chenopodium quinoa* Wild) seeds as affected by baking and cooking conditions. Food and Nutrition Sciences. 2012; 3:1150-1155.
4. Carciochi RA, Galván-D’Alessandro L, Vandendriessche P. Effect of Germination and Fermentation Process on the Antioxidant Compounds of Quinoa Seeds. Plant Foods for Human Nutrition. 2016; 71(4):361-367.
5. Carciochi RA, Dimitrov K, Galván D´Alessandro L. Effect of malting conditions on phenolic content, Maillard reaction products formation, and antioxidant activity of quinoa seeds. Journal of Food Science and Technology, 2013, 1- 8.
6. Carciochi RA, Manrique GD, Dimitrov K. Changes in phenolic composition and antioxidant activity during germination of quinoa seeds (*Chenopodium quinoa* Wild). International Food Research Journal. 2014; 21(2):767-773.
7. Carvalho FGD, Ovídio PP, Padovan GJ, Junior AAJ, Marchini JS, Navarro AM. Metabolic parameters of postmenopausal women after quinoa or corn flakes intake – a prospective and double-blind study. International

Journal of Food Sciences and Nutrition. 2013; 65(3):380-385.
8. Chandran S. Effect of extrusion on physico-chemical properties of quinoa-cassava extrudates fortified with cranberry concentrate. Thesis. Graduate School-New Brunswick Rutgers, The State University of New Jersey, 2015, 45-61.
9. Dini I, Tenore GC, Dini A. Antioxidant compound contents and antioxidant activity before and after cooking in sweet and bitter *Chenopodium quinoa* seeds. Food Science and Technology. 2010; 43:447-451.
10. Dini I, Tenore GC, Dini A. Phenolic constituents of Kancolla seeds. Food Chem. 2004; 84:163-8.
11. Enrione CJI, Diaz CP, Osorio LF. Method for the formulation of a gel-format foodstuff for use as a nutritional foodstuff enriched with peptides and maltodextrins obtained from quinoa flour. Patent Application CA2860041 A1, 2013.
12. Escuredo O, Martın GMI, Moncada GW, Fischer S, Hierro HJ. Amino acid profile of the quinoa (*Chenopodium quinoa Willd*) using near infrared spectroscopy and chemometric techniques. Journal of Cereal Science. 2014; 60:67-74.
13. FAO. Quinoa: An ancient crop to contribute to world food security. Regional Office for Latin America and the Caribbean, 2011.
14. Farinazzi-Machado FMV, Barbalho SM, Oshiiwa M, Goulart R, Junior PO. Use of cereal bars with quinoa (*Chenopodium quinoa* Willd) to reduce risk factors related to cardiovascular diseases. Cienc Technol Aliment Campinas. 2012; 32(3):239-44.
15. Felipe CX, Guamis LB, Quevedo TJM, Trujillo MAJ. Liquid product of vegetable origin as milk substitute. Patent Application EP1338206 A1, 2003.
16. Galvez VA, Miranda M, Vergara J, Uribe E, Puente L, Martinez EA. Nutrition facts and functional potential of quinoa (*Chenopodium quinoa* wild.), an ancient Andean grain. Journal of Food Science and Agriculture. 2010; 90(15):2541-47.
17. Giménez MA, Drago SR, Bassett MN, Lobo MO, Sammán NC. Nutritional improvement of corn pasta-like product with broad bean (*Vicia faba*) and quinoa (*Chenopodium quinoa*). Food chemistry. 2016; 199:150-56.
18. Gómez-Caravaca AM, Iafelice G, Verardo V, Marconi E, Caboni MF. Influence of pearling process on phenolic and saponin content in quinoa. Food chemistry. 2014; 157:174-178.
19. Graf BL, Rojas-Silva P, Rojo LE, Delatorre-Herrera J, Baldeon ME, Raskin I. Innovations in Health Value and Functional Food Development of Quinoa (*Chenopodium quinoa* Willd). Comprehensive Reviews in Food Science and Food Safety. 2015; 14:431- 445.
20. Hafele W, Sassin W. Resources and endowments, an outline of future energy systems. in P.W Hemily and M.N. Ozdas (eds.). Science and Future Choirs (Oxford: Clarendon Press, 1979.
21. Izdajatelj. New challenges for sustainable rural development in the 21st century. Journal for Geography, 2010, 5(1).
22. James LEA. Quinoa (*Chenopodium quinoa* Wild): composition, chemistry, nutritional and functional properties. Advances in Food and Nutrition Research. 2009; 58:1-32.
23. Jancurová M, Minarovičová L, Dandár A. Quinoa – a Review. Czech J Food Sci. 2009; 27:71-79.
24. Kamelgard JI. Inventor. Quinoa-based beverages and method of creating quinoa-based beverages. Patent Application EP2670833 A1, 2013.
25. Kanensi OJ, Ochola S, Gikonyo NK, Makokha A. Optimization of the Period of Steeping and Germination of Amaranth Grain. Journal of Agriculture and Food Technology. 2011; 1(6):101-105.
26. Kaur I, Tanwar B, Reddy M, Chauhan A. Vitamin C, total polyphenols and antioxidant activity in raw, domestically processed and industrially processed Indian (*Chenopodium quinoa*) seeds. Journal of Applied Pharmaceutical Science. 2016; 6(4):139-145.
27. Kruger M. Composition, useful for treating hair, comprises quinoa protein a quaternary ammonium compound comprising e.g. esterquats and quaternary imidazoline compound, and a nourishing fatty component comprising silicone and/or oil body. Patent Application DE102011085217 A1, 2012.
28. Miranda M, Vega-Gálvez A, López J, Parada G, Sanders M, Aranda M *et al*. Impact of air-drying temperature on nutritional properties, total phenolic content and antioxidant capacity of quinoa seeds (*Chenopodium quinoa* Willd.). Industrial Crops and Product. 2010; 32:258-263.
29. Msika P. Composition containing a quinoa grain extract for dermatological use. U.S. Patent Appliction 20100136144 A1, 2012.
30. Nickel J, Pio Spanier L, Botelho FT, Gularte MA, Helbig E. Effect of different types of processing on the total phenolic compound content, antioxidant capacity, and saponin content of *Chenopodium quinoa* Willd grains. Food chemistry. 2016; 209:139-143.
31. Nowak V, Du J, Charrondière UR. Assessment of the nutritional composition of quinoa (*Chenopodium quinoa Wild*). Food Chemistry. 2015; 193:47-54.
32. Oelke EA, Putnam DH, Teynor TM, Oplinger ES. Quinoa. Alternative field crops manual. http://www.hort.purdue.edu/newcrop/afcm/quinoa.html, 2012.
33. Park SH, Naofumi M. Changes of bound lipids and composition of fatty acids in germination of quinoa seeds. Food science and technology. 2004; 10(3):303-306.
34. Pineli LDLDO, Botelho RBA, Zandonadi RP, Solorzano JL, Oliveira GTD, Reis CEG *et al*. Low glycemic index and increased protein content in a novel quinoa milk. Food Science and Technology. 2015; 63:1261-1267.
35. Pouvreau LA, Kanning MW, Velde FVD. Processing quinoa for improved protein-to-carbohydrate formulations. U.S. Patent Application 20140161950 A1, 2014.
36. Repo-Carrasco-Valencia, Serna. Quinoa (*Chenopodium quinoa*, Willd.) as a source of dietary fiber and other functional components. *Ciênc. Tecnol.* Aliment., Campinas. 2009; 31(1):225-230.
37. Rothschild J, Kurt A, Rosentrater CO, Signh M, Menutti L, Jambazian P *et al*. Influence of quinoa roasting on sensory and physicochemical properties of allergen-free, glutenfree cakes. International journal of food science & technology, 2015.
38. Ruales J, De Grijalva Y, Lopez-Jaramillo P, Nair BM. The nutritional quality of infant food from quinoa and its

effect on the plasma level of insulin-like growth factor-1 (IGF-1) in undernourished children. International Journal of Food Science & Nutrition. 2002; 53:143-54.
39. Ruiz GA, Opazo-Navarrete M. Exploring novel food proteins and processing technologies: a case study on quinoa protein and high pressure-high temperature processing. Thesis, 2016.
40. Saalia F, Phillips RD. Degradation of aflatoxins by extrusion cooking: Effects on nutritional quality of extrudates. LWT- Food Science and Technology. 2011; 44(6):1496-1501.
41. Scanlin LA, Burnett C. Quinoa grain processing and products. U.S. Patent Application 20100196569 A1, 2010.
42. Scanlin L, Stone M. Purified plant protein is separated from solvent extraction; as food ingredients, infant formula ingredients, cosmetic ingredients, pet food ingredients, and animal feed supplements. U.S. Patent 7563473 B2, 2009.
43. Schlick G, Bubenheim DL. Quinoa: Candidate crop for NASA's Controlled Ecological Life Support Systems. In: J Janick (ed.), Progress in new crops. ASHS Press, Arlington, VA, 1996, 632-640.
44. Soundharya Chandran. Effect of extrusion on physico-chemical properties of quinoa-cassava extrudates fortified with cranberry concentrate. Thesis, 2015.
45. Silva JA, Pompeu G, Olavo C, Gonçalves DB, Spehar CR. The importance of heat against antinutritional factors from *Chenopodium quinoa* seeds. Food Science and Technology. 2015; 35(1):74-82.
46. Singer NS, Tang P, Chang H, Dunn JM. Carbohydrate cream substitute. U.S. Patent 4911946 A, 1990.
47. Takao T, Watanabe N, Yuhara K, Itoh S, Suda S, Tsuruoka Y *et al*. Hypocholesterolemic Effect of Protein Isolated from Quinoa (*Chenopodium quinoa* Wild) Seeds. Food Science and Technology Research. 2005; 11(2):161-167.
48. Thomas R. Process for the treatment of quinoa seeds, and product obtained. U.S. Patent 5264231 A, 1995.
49. Vega-G'alvez A, Miranda M, Vergara J, Uribe E, Puente L, Martı'nez EA. Nutrition facts and functional potential of quinoa (*Chenopodium quinoa* Wild), an ancient Andean grain: a review. Journal of the Science of Food and Agriculture. 2010; 90(15):2541-2547.
50. Zevallos VF, Ellis HJ, Suligoj T, Herencia LI, Ciclitira PJ. Variable activation of immune response by quinoa (*Chenopodium quinoa* Willd.) prolamins in celiac disease. The American Journal of Clinical Nutrition. 2012; 96(2):337-344.
51. Zevallos VF, Herencia LI, Chang F, Donnelly S, Ellis HJ, Ciclitira PJ. Gastrointestinal effects of eating quinoa (*Chenopodium quinoa* Willd.) in celiac patients. *The* American Journal of Gastroenterology. 2014; 109(2):270-278.